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Topology optimization of structures and infill for additive manufacturing

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Topology optimization (TO) [1] is a widely used tool for generating optimal structures for subsequent realization by additive manufacturing (AM) methods. TO is a numerical method that, based on iterated finite element analyses, gradient-based optimization algorithms and design parameterizations described by point clouds, delivers optimal but often rather complex topologies. As such, TO is a design method that takes full advantage of the large design freedom offered by AM technologies. Much recent effort in the TO community has been devoted to the development of algorithms that take manufacturing constraints into account, such as overhang angles, printing directions and minimization of support material. In this talk we will discuss recent developments in simultaneous design of structures and their infill.

Infill in AM is often used to save material consumption and weight. Infill is also used as a design gimmick to illustrate the capabilities of AM to mimic natural creations like honeycombs and bone structure. Partly for manufacturing reasons, infill microstructure is often built as open-walled foam structures. However, as maybe unknown by many, open-walled microstructures are not optimal with respect to stiffness [2]. Even if one builds structures with uniform and stiffer closed-walled infill, it does not beat simple solid structures with regards to stiffness. On the other hand, porous infill structures may posses an advantage with regards to buckling stability compared to their solid counterparts [3].

The talk will discuss above issues in more detail and present recent developments with regards to topology optimization with uniform and isotropic infill [3, 4, 5], anisotropic infill for fixed outer geometries [6], simultaneous anisotropic infill and structural design [7], as well as recent developments in multi-scale topology optimization approaches that may speed up the previously mentioned approaches [8].

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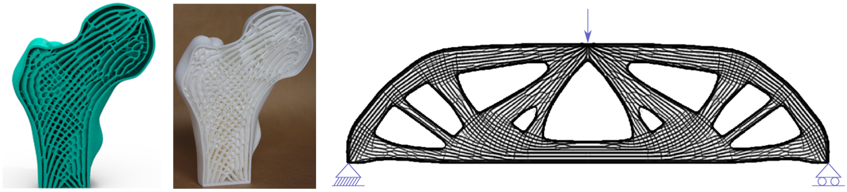

Figure 1: Examples of topology optimization of structures with infill. From [6] (left) and [7] (right).

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